3ND-P&PO-2491

UNCLASSIFIED

Cr.c 17

1956

AD 270666

TECHNICAL REPORT

MATERIAL LABORATORY

NEW YORK NAVAL SHIPYARD
BROOKLYN 1, NEW YORK

XEROX

12-2-1

3ND-NYNS-900-P-1A

UNCLASSIFIED

RESEARCH REPORT
on
THE THERMAL RADIATION CHARACTERISTICS
OF NYLON FABRIC ASSEMBLIES

Submitted by
The Clothing Supply Office
(Research and Development Division)
U.S. Naval Supply Activities
Brooklyn, N.Y.

Lab. Project 5046-3, Part 96, Final Report
AFSWP-954 NS-081-001
Technical Objective AW-7
5 June 1956

L. Banet J. Bracciaventi

Optics and Nucleonics Branch
J. M. McGREEVY, Head

Superintending Engineer
GEO. J. DASHEFSKY

The Director
CAPTAIN A. B. JONES, JR., USN

NAVAL MATERIAL LABORATORY
New York Naval Shipyard
Brooklyn 1, New York

UNCLASSIFIED

SUMMARY

The thermal radiation characteristics of four nylon fabric assemblies, submitted by the Clothing Supply Office (Research and Development Division), U. S. Naval Supply Activities, Brooklyn, New York, have been evaluated. The critical thermal energies required for destruction of the fabric assemblies, were determined. The critical thermal energies required to produce a 2+ mild burn to skin behind the fabric were computed from the temperature rise of an underlying skin simulant attendant upon irradiation of the fabric assembly.

For the measurement of the critical thermal energies for cloth destruction the dynamic-exposure carbon-arc source with paraboloidal mirrors for collimating and condensing the emitted radiation was employed. The 11-mm static-exposure carbon-arc source with an ellipsoidal mirror for collecting and condensing the radiation was employed to determine the temperature-time characteristics of the polyethylene skin simulant behind the cloths. Using the temperature history measurements, the critical energies, corresponding to a 2+ mild burn underneath the fabric assemblies were calculated.

TABLE OF CONTENTS

ADMINISTRATIVE INFORMATION

1. This investigation is part of the general Thermal Radiation program, proposed by Commander, New York Naval Shipyard confidential letter S99/L5, Serial 960-92, of 15 March 1950 and formally approved by Bureau of Ships speedletter S99-(0)(348), Serial 348-75, of 6 April 1950. The Thermal Radiation studies at the Naval Material Laboratory are under the supervision of the Armed Forces Special Weapons Project. This investigation was requested in Clothing Supply Office (Research and Development Division) letters 1D12-1:lg, A11/NT 53.01 of 4 March 1955 and 20 July 1955.

ACKNOWLEDGEMENTS

2. This investigation was planned and executed under the direction of T. I. Monahan, Supervisor of the Optics Section. W. L. Derksen furnished valuable assistance in the measurements involving the skin simulant.

INTRODUCTION

3. One of the major effects of atomic weapons on personnel arises from the instantaneous thermal radiation which may cause severe burns at relatively large distances from the center of the detonation. Studies carried out at the University of Rochester have indicated that the production of a so-called 2+ mild burn on uncovered porcine skin require, only 2.6 to 4.3 cal/cm^2 for rectangular impulses with exposure times of 0.1 to 1.0 seconds. (1) While clothing offers some protection to personnel by virtue of its insulating properties, the amount of heat transferred directly or by means of exothermic reactions by the clothing may result in a sufficient rise in temperature, to cause an incapacitating burn. A second degree burn in the human, corresponding to vesiculation, is sufficiently injurious and painful to be considered serious, if not incapacitating and it, therefore, has been adopted as the threshold for the production of casualties. As the energy required to produce 2+ burn in pig skin (spotty whiteness or coagulation) is comparable with that required to cause a second degree burn in humans, the 2+ pig-burn criterion is frequently applied when estimating the number of casualties in a given military situation.

(1) Bibliography

4. Previous studies conducted at the Naval Material Laboratory have indicated that variations in physical parameters (absorptance, nature of fiber material, weight of fabric) may alter considerably the resistance of fabrics to intense thermal radiation. (2) In addition to these parameters, which affect the damage to the cloths directly, physiological burns behind clothing are influenced by other physical factors, such as the thermal and optical constants of the skin and the transmittance and porosity of the fabrics. Recently laboratory methods for evaluating physiological burns behind fabrics, employing a plastic skin simulant, have been developed at the Naval Material Laboratory; the temperature history of the skin simulant behind an irradiated fabric system is measured and is interpreted in terms of the corresponding physiological burn, using methods developed at the Laboratory.

5. The Bureau of Supplies and Accounts, Department of the Navy, has assigned to the Clothing Supply Office (Research and Development Division); U. S. Naval Supply Activities, Brooklyn, New York, the responsibility for the development of garments designed to minimize the effects of the thermal radiation of nuclear weapons. In conjunction with this program, the Clothing Supply Office requested the Naval Material Laboratory to evaluate the thermal radiation characteristics of a group of four nylon fabric assemblies. The present report deals with the evaluation of these fabrics.

APPARATUS AND METHODS EMPLOYED

FABRIC ASSEMBLIES INVESTIGATED

6. For this evaluation, the Clothing Supply Office submitted four nylon fabric assemblies. The last two, designated as No. 14 and No. 15, consist of fabrics of the A-2 and A-1 cold weather uniforms of the Navy. The first assembly (No. 10b) consists of 3.5 oz. nylon twill, single coated neoprene, over knitted, 9.5 oz., nylon fleece and the second (No. 10b-1) the same two fabrics over waffle-knit cotton underwear.

CRITICAL THERMAL ENERGIES

7. The 11-mm dynamic-exposure carbon-arc source which utilizes two paraboloidal mirrors for collimating and condensing the emergent radiation was employed for the determination of the critical thermal energies of the fabric assemblies. The exposure times varied from 0.3 to 0.6 seconds for radiant exposures up to 53 cal/cm^2 and from 0.6 to 1.2 seconds for radiant exposures ranging from 53 to 106 cal/cm^2. The distribution of irradiance with time is essentially Gaussian, with time of maximum of irradiance approximately one-half the total exposure time. The maximum intensity of the source is 85 cal/cm^2 sec which is reduced by means of attenuating screens. The specimens were exposed to increasing amounts of thermal radiation until the first visual damage to the cloth surfaces was observed; the exposures were continued until at least the first fabric layer was completely destroyed, either during irradiance or as a result of afterflame.

---

(2) Bibliography

TRANSFER OF HEAT THROUGH CLOTHING

8. For determining the heat transfer through the clothing layers, specimens of the nylon fabric assemblies, 1.5 x 1.5 inches, were fastened on metal holders having a central, square aperture, 1-1/8 inches wide, mounted firmly, but with no tension, over the polyethylene skin simulant. To measure the temperature rise of the skin simulant, a thermocouple of No. 30 iron-constantan wire is imbedded in the center of this block at a depth of 0.023 cm. The temperature rise is indicated by a recording potentiometer. In the source employed for these measurements the carbon arc is mounted at the primary focus of an ellipsoidal mirror and fabric specimens are mounted at the secondary focus. The exposure time is controlled by a knife-bladed shutter mechanism, solenoid activated and energized by an electronic timer. The source irradiance is varied by means of attenuating screens.

9. The absorptance-corrected polyethylene skin simulant (4) was placed in contact with the various fabric systems, but with no pressure applied, and the combination was irradiated at an irradiance level of 10 cal/cm^2 sec. The temperature histories obtained as a result of the irradiation of the cloth were analyzed by the methods outlined in the Naval Material Laboratory report on the development of the polyethylene skin simulant; (3) the radiant exposure to cause a 2+ mild burn was computed.

RESULTS

CRITICAL RADIANT EXPOSURES

10. The critical radiant exposures of the nylon fabric systems are given in Table 1. The significant data are summarized as follows:

a. Initial Effects. The three assemblies with an outer layer of nylon twill, designated as 10b, 10b-1 and 15, showed initial damage, consisting of melting, after exposures of 5.6, 6.7 and 8.5 cal/cm^2, respectively. The outer cotton layer of the fourth assembly, (No. 14) was charred at a radiant exposure of 11 cal/cm^2.

b. Destruction of First Layer. The destruction of the outer layer of the cotton fabric in the A-2 cold weather combination, coincided with destruction of the second layer of this assembly and occurred at a radiant exposure of 18 cal/cm^2. The destruction of the outer-layers of assemblies 10b, 10b-1 and 15 occurred at 12, 14, and 18 cal/cm^2 respectively.

c. Flaming During Exposure. The three assemblies with nylon outer-layers (10b, 10b-1, 15) flamed during exposure to approximately 55 cal/cm^2.

(3)(4) Bibliography

d. Destruction of Nylon Fleece. The nylon fleece, forming the second layer with nylon surface layers, 15, 10b and 10b-1, melted through at 68, 75, and 84 cal/cm^2 respectively.

e. Additional Layers. The third layer of the A-1 cold weather combination was destroyed after exposure to 83 cal/cm^2. The cotton waffle knit underwear, forming the innermost layer of the two cold-weather combinations, remained undamaged, even when irradiated by a radiant exposure of 106 cal/cm^2.

TRANSFER OF HEAT THROUGH CLOTHING

11. The radiant exposures required to produce a 2+ mild burn under the fabric assemblies, are listed in Table 2. Details of the results are discussed below.

a. Two-layer Assembly. The temperature histories measured under the only two-layer nylon assembly investigated (10b) indicate that a 2+ mild burn is to be expected after a radiant exposure of 30 cal/cm^2.

b. Three-layer Assemblies. The two three-layer assemblies evaluated 10b-1 and 14, require 65 and 56 cal/cm^2, respectively, to cause a 2+ mild burn. The addition of the waffle-knit to the two-layer assembly above causes an increase in the radiant exposure for a 2+ mild burn from 30 to 65 cal/cm^2. On the other hand, replacement of the top layer, consisting of neoprene coated nylon twill, by cotton oxford causes a reduction in the required radiant exposure for a 2+ mild burn from 65 to 56 cal/cm^2; this assembly was the only one of the four investigated which sustained afterflame.

c. Six-layer Assembly. For a radiant exposure of 127 cal/cm^2 the temperature rise under the A-1 cold weather combination, designated as 15, the temperature rise was only 12°C; this rise is considerably lower than that required to produce a 2+ mild burn under this combination of layers.

d. Hazard of Molten Nylon During the investigation of the nylon fabric assemblies, it was observed that heated nylon fabric forms a melt which produces an instantaneous and painful burn as soon as it comes in contact with uncovered skin. The molten material adheres strongly to human skin. The relatively low critical radiant exposure required for destruction of the outer nylon fabrics indicates an additional hazard of this fabric, particularly where the cloth comes in direct contact with the skin.

ANALYSIS

12. Review of the experimental findings indicates the following trends:

a. As compared to cotton, the nylon fabrics are more vulnerable to effects of thermal radiation.

b. As would be expected, thermal radiation damage to skin is considerably reduced with an increase in the number of layers of clothing. The six layer assembly, when not destroyed, offers excellent protection against burns resulting from thermal transfer through the layers. It should be noted that the accuracy of the data for the multilayer assemblies is doubtful as the number of layers is increased, because of the limited area of irradiation relative to the thickness of the assembly.

c. Because molten nylon causes severe burns on uncovered skin and because nylon fabrics are rather easily affected by incident thermal radiation, nylon fabrics present a particular hazard when employed in surface layers and in contact with unprotected skin areas (hands, face etc.)

d. Since cotton in contact with an underlying layer of nylon was found to cause destruction of the nylon layer simultaneously with its own destruction, the resistance of nylon under cotton is low.

CONCLUSIONS

13. The following conclusions may be drawn from the results of this study:

a. The amount of protection offered by a single layer of the nylon fabrics investigated is small, since these layers show initial effects after exposures to less than 9 cal/cm^2 and destruction after exposures to less than 18 cal/cm^2.

b. It was observed that flames develop during radiant exposures of approximately 55 cal/cm^2 on the nylon fabric assemblies.

c. The numerous layers contained in the cold weather combinations provide considerable protection against thermal radiation hazards. The last layer of these assemblies, consisting of cotton waffle knit underwear, remained undamaged up to a radiant exposure of 106 cal/cm^2. An exposure of 127 cal/cm^2 did not cause a 2+ mild burn under the A-1 cold weather combination.

d. A 2+ mild burn may be expected after exposure to 30 cal/cm^2 on one of the two layer assemblies (No. 10b). The same burn occurs after 56 cal/cm^2 under the first three-layers assembly (No. 14) and after 65 cal/cm^2 under the second three-layer assembly (No. 10b-1).

e. If molten nylon, such as produced in radiation exposures, comes in contact with bare skin, it will produce instantaneous and painful burns and can only be removed with difficulty.

Approved:

A. B. JONES, Jr., CAPTAIN USN
The Director

cv

B I B L I O G R A P H Y

1. Morton, J.H., Kingsley, H.D., Pearse, H.E., Studies of Flash Burns. The Protective Effects of Certain Fabrics. Surg. Gync. Obst., 94:497 (1952).

2. Naval Material Laboratory, Critical Thermal Energies of Textile Materials, Prepared by the Quartermaster Research and Development Laboratories. Lab. Project 5046-3, Part 6 (Mar 1952)(Confidential).

3. Naval Material Laboratory. The Use of Polyethylene as a Physical Measuring System for Evaluating Physiological Burns Behind Cloth Fabrics. Lab. Project 5046-3, Part 42 (Nov 1954)(Unclassified).

4. Naval Material Laboratory. A Method to Improve the Optical Characteristics of the Black Polyethylene Skin Simulant Lab. Project 5046-3, Part 78 (March 1955) (Unclassified)

TABLE 1

CRITICAL RADIANT EXPOSURES OF CLOTHING ASSEMBLIES
Submitted By
U. S. Naval Supply Activities, Brooklyn, N. Y., Department of the Navy

NSA Designation	Description of Clothing Assembly	Description of Effect	Critical Exposure (cal/cm^2)
10b	3.5 oz. Nylon twill Low count, single coated Neoprene; 9.5 oz. Nylon Fleece, Knitted	Outer surface begins to melt	5.6
		Outer layer melted through	12
		Top surface of Nylon Fleece begins to melt	24
		Flames during exposure	56
		Nylon Fleece melted through	75
10b-1	3.5 oz. Nylon Twill, low count, single coated Neoprene; 9.5 oz. Nylon Fleece, Knitted; Cotton Waffle-Knit underwear	Outer surface begins to melt	6.7
		Outer layer melted through	14
		Top surface of Nylon Fleece begins to melt	36
		Flames during exposure	56
		Nylon Fleece melted through	84
14	A-2 Cold Weather Combination; 9.0 oz. Cotton Oxford, 9.5 oz. Nylon Fleece, Cotton Waffle-Knit underwear	Cotton outer layer charred	11
		Outer layer & Nylon Fleece destroyed by after flame & after glow	18
15	A-1 Cold Weather Combination; 3.5 oz. Nylon Twill 9.5 oz. Nylon Fleece; 1.8 oz. Nylon Twill; Acetate Batting; 1.8 oz. Nylon Twill Cotton Waffle-Knit Underwear	Nylon Twill outer layer begins to melt	8.5
		Outer layer melted through	18
		Flames during exposure	54
		Top surface of Nylon Fleece begins to melt	58
		Nylon Fleece melts through	68
		Third layer (1.8 oz. Nylon Twill) melts through)	83

TABLE 2

EXPOSURES REQUIRED TO PRODUCE 2+ MILD BURNS UNDER FABRIC ASSEMBLIES

submitted by
U. S. Naval Supply Activities, Brooklyn, New York, Department of the Navy

Assembly	No. of Layers	Time (sec)	Irradiance (cal/cm^2 sec.)	Exposure (cal/cm^2)	Temp. Rise (°C)	Effect on Fabric	Duration of ½ max. temp. (sec)	COMPUTED Crit. Temp. Rise °C	COMPUTED Crit. Exposure 2+ Mild Burn (Cal/cm^2)
10b	2	2.72	11.7	31.8	39	Burned Through	16	37	30
10b-1	3	5.00	12.2	61.2	31	2 layers Burned through	37	33	65
14	3	4.53	12.3	55.7	36	Afterflame & Afterglow	22	36	56
15	6	10.0	12.7	127	12	Afterglow 4th layer Charred	142	30	>250

DISTRIBUTION LIST NO. 100
Thermal Radiation Reports
(Research)

19 July 1956

ARMY

ADDRESSEE	NO. OF COPIES
Assistant Deputy Chief of Staff for Military Operations, Dept. of the Army, Washington 25, D. C. ATTN: Assistant Executive, (R&SW)	1
Chief of Research and Development, Dept. of the Army, Washington 25, D. C. ATTN: Atomics Division	1
Chief of Ordnance, Dept. of the Army, Washington 25, D. C. ATTN: ORDTX-AR	1
Chief Signal Officer, Dept. of the Army, Washington 25, D. C. ATTN: SIGOP	3
The Surgeon General, Dept. of the Army, Washington 25, D. C. ATTN: Ch, R&D Div	1
Chief Chemical Officer, Dept. of the Army, Washington 25, D. C.	2
Chief of Engineers, Dept. of the Army, Washington 25, D. C. ATTN: ENGNB	3
Research Branch, Office of Research and Development, The Quartermaster General, Dept. of the Army, Washington 25, D. C.	1
Chief of Transportation, Dept. of the Army, Washington 25, D. C. ATTN: Military Planning & Intelligence Div.	1
Commanding General, Continental Army Command, Ft. Monroe, Va.	4
President, Board #1, Headquarters, Continental Army Command, Ft. Sill, Oklahoma	1
President, Board #2, Headquarters, Continental Army Command, Ft. Knox, Ky.	1
President, Board #4, Headquarters, Continental Army Command, Ft. Bliss, Texas	1

ADDRESSEE	ARMY (Cont'd)	NO. OF COPIES
Commander-in-Chief, FECOM, APO 500, San Francisco, Calif. ATTN: ACofS J-3		2
Commandant, Command & General Staff College, Ft. Leavenworth, Kans. ATTN: ALLLS(AS)		1
Commanding General, Army Medical Service School, Brooke Army Medical Center, Ft. Sam Houston, Texas		1
Director, Special Weapons Development Office, Headquarters, Continental Army Command, Ft. Bliss, Texas		1
Commandant, Walter Reed Army Institute of Research, Walter Reed Army Medical Center, Washington 25, D. C. ATTN: Dept. of Biophysics		1
Commandant, Chemical Corps School, Chemical Corps Training Command, Ft. McClellan, Ala.		1
Commanding General, Research & Engineering Command, Army Chemical Center, Md. ATTN: Deputy for RW & Non-Toxic Material		2
Commanding General, The Engineer Center, Ft. Belvoir, Va. ATTN: Ass't. Commandant, Eng School		3
Commanding General, Aberdeen Proving Ground, Aberdeen Proving Ground, Md. ATTN: Director, Ballistics Research Laboratory		2
Commanding Officer, Engineer Research & Development Laboratory, Ft. Belvoir, Va. ATTN: Chief, Tech Intelligence Branch		1
Commanding Officer, Picatinny Arsenal, Dover, N. J. ATTN: ORDBB-TK		1
Commanding Officer, Frankford Arsenal, Philadelphia 37, Pa. ATTN: Col Tewes Kundel		1
Commanding Officer, Army Medical Research Laboratory, Ft. Knox, Ky.		1

Dist List No. 100 (Cont'd)

ADDRESSEE ARMY (Cont'd)	NO. OF COPIES
Commanding Officer, Chemical & Radiological Lab., Army Chemical Center, Md. ATTN: Tech Library	2
Commanding Officer, Transportation Command, Ft. Eustis, Va. ATTN: Special Projects Division, Technical Intelligence Branch	1
Director, Technical Documents Center Evans Signal Laboratory, Belmar, N. J.	1
Director, Waterways Experiment Station, P. O. Box 631, Vicksburg, Miss. ATTN: Library	1
Director, Operations Research Office, The Johns Hopkins University, 7100 Connecticut Avenue, Chevy Chase, Md., Washington 15, D. C.	1
Chemical Biological and Radiological Warfare Branch Quartermaster Research & Development Command, Quartermaster Research & Development Center, Natick, Mass.	2
NAVY	
Chief of Naval Operations, Dept. of the Navy, Washington 25, D. C. ATTN: OP-36	2
Chief of Naval Operations, Dept. of the Navy, Washington 25, D. C. ATTN: OP-03EG	1
Chief, Bureau of Medicine & Surgery, Dept. of the Navy, Washington 25, D. C. ATTN: Special Weapons Defense Division	1
Chief, Bureau of Ordnance, Dept. of the Navy, Washington 25, D. C.	1
Chief of Naval Personnel, Dept. of the Navy, Washington 25, D. C. ATTN: Pers C-115	1
Chief, Bureau of Ships, Dept. of the Navy, Washington 25, D. C. ATTN: Code 348	2
Code 312	4

ADDRESSEE NAVY (Cont'd)	NO. OF COPIES
Chief, Bureau of Supplies and Accounts, Dept. of the Navy, Washington 25, D. C.	1
Chief, Bureau of Yards & Docks, Dept. of the Navy, Washington 25, D. C. ATTN: D-440	1
Chief, Bureau of Aeronautics, Dept. of the Navy, Washington 25, D. C.	2
Chief of Naval Research, Dept. of the Navy, Washington 25, D. C. ATTN: Code 811	1
Commander-in-Chief, U. S. Pacific Fleet, FPO, San Francisco, Calif.	1
Commander-in-Chief, U. S. Atlantic Fleet, U. S. Naval Base, Norfolk 11, Va.	1
Commandant of the Marine Corps, Dept. of the Navy, Washington 25, D. C. ATTN: Code A03H	4
President, U. S. Naval War College, Newport, R. I.	1
Superintendent, U. S. Naval Postgraduate School, Monterey, Calif.	1
Commanding Officer, U. S. Naval Schools Command, U. S. Naval Station, Treasure Island, San Francisco, Calif.	2
Commanding Officer, U. S. Fleet Training Center, Naval Base, Norfolk 11, Va. ATTN: Special Weapons School	2
Commanding Officer, U. S. Fleet Training Center, Naval Station, San Diego 36, Calif. ATTN: SPWP School	2
Commanding Officer, Air Development Squadron 5, VX-5, U. S. Naval Air Station, Moffett Field, Calif.	1

ADDRESSEE	NAVY (Cont'd)	NO. OF COPIES
Commanding Officer, U. S. Naval Damage Control Training Center, Naval Base, Philadelphia 12, Pa. ATTN: ABC Defense Course		1
Commanding Officer, U. S. Naval Unit, Chemical Corps School, Army Chemical Training Center, Ft. McClellan, Alabama		1
Commander, U. S. Naval Ordnance Laboratory, White Oak, Silver Spring 19, Md. ATTN: EE R		 1 1
Commander, U. S. Naval Ordnance Test Station, China Lake, Calif.		1
Commanding Officer, U. S. Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Md.		1
Director, U. S. Naval Research Laboratory, Washington 25, D. C. ATTN: Code 2029		1
Commander, New York Naval Shipyard, Brooklyn 1, N. Y. ATTN: Director, The Material Laboratory		1
Commanding Officer & Director, U. S. Naval Electronics Laboratory, San Diego, Calif. ATTN: Code 4223		1
Commanding Officer, U. S. Naval Radiological Defense Laboratory, San Francisco 24, Calif. ATTN: Tech Info Div		3
Commander, U. S. Naval Air Development Center, Johnsville, Pa.		1
Commanding Officer, Clothing Supply Office, Code 10-0, 29th Street & 3rd Avenue, Brooklyn 32, N. Y.		1
Commanding Officer, Naval Medical Field Research Laboratory, Camp Lejune, N. C.		1

Dist List No. 100

ADDRESSEE	AIR FORCE	NO. OF COPIES
Assistant for Atomic Energy, Headquarters, U. S. Air Force, Washington 25, D. C.		1
Director of Operations, Headquarters, U. S. Air Force, Washington 25, D. C. ATTN: Operations Analysis		1
Director of Plans, Headquarters, U. S. Air Force, Washington 25, D. C. ATTN: War Plans Div.		1
Director of Requirements, Headquarters, U. S. Air Force, Washington 25, D. C. ATTN: AFDRQ-SA/M		1
Director of Research & Development, Headquarters, Washington 25, D. C. ATTN: Combat Components Div.		1
Director of Intelligence, Headquarters, U. S. Air Force, Washington 25, D. C. ATTN: AFOIN-1B2		2
The Surgeon General, Headquarters, U. S. Air Force, Washington 25, D. C. ATTN: Bio Defense Br., Prev Med Division		1
Commander-in-Chief, Strategic Air Command, Offutt AFB, Nebraska ATTN: Chief, Operations Analysis		1
Commander, Tactical Air Command, Langley Air Force Base, Va. ATTN: Doc Sec Branch		1
Commander, Air Defense Command, Ent Air Force Base, Colorado		1
Commander, Air Materiel Command, Wright-Patterson Air Force Base, Ohio		2
Commander, Air Training Command, Scott Air Force Base, Ill. ATTN: DCS/O GTP		1
Commander, Air Research & Development Command, P. O. Box 1395, Baltimore 3, Md. ATTN: RDDN		3
Commander, Air Proving Ground Command, Eglin Air Force Base, Fla. ATTN: AG/TRB		1

ADDRESSEE	AIR FORCE (Cont'd)	NO. OF COPIES
Director, Air University Library, Maxwell Air Force Base, Ala.		2
Commander, Flying Training Air Force, Waco, Texas ATTN: Director of Observer Training		2
Commander, Crew Training Air Force, Randolph Air Force Base, Randolph Field, Tex. ATTN: 2GTS, DCS/O		1
Commander, Technical Training Air Force, Gulfport, Miss. ATTN: TA&D		1
Commander, U. S. Air Force School of Aviation Medicine, Randolph Air Force Base, Randolph Field, Texas		2
Commander, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio ATTN: WCOSI		1
Commander, Air Force Cambridge Research Center, L. G. Hanscom Field, Bedford, Mass. ATTN: CRQST-2		1
Commander, Air Force Special Weapons Center, Kirtland Air Force Base, N. M. ATTN: Technical Information and Intelligence		3
Commander, U. S. Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio ATTN: Resident College		1
Commander, Lowry Air Force Base, Denver, Colo. ATTN: Dept of Armament Training		1
	OTHER DOD ACTIVITIES	
Director, Weapons Systems Evaluation Group, OSD, Washington 25, D. C.		1
U. S. Documents Officer, Office of the United States National Military Representative - SHAPE, APO 55, New York, N. Y.		1
Assistant Secretary of Defense, (Research and Development), Washington 25, D. C. ATTN: Tech Library		1
Commandant, Armed Forces Staff College, Norfolk 11, Va. ATTN: Secretary		1

ADDRESSEE	NO. OF COPIES
OTHER DOD ACTIVITIES (Cont'd)	
Commander, Field Command, AFSWP, PO Box 5100, Albuquerque, N. M.	6
Chief, Armed Forces Special Weapons Project, Washington 25, D. C.	15
PANEL ON THERMAL RADIATION	
Massachusetts Institute of Technology, Director, Division of Defense Laboratories, Lincoln Laboratory, Cambridge 19, Mass. (For Prof. Hoyt C. Hottel)	1
Dr. Edward O. Hulburt, Senior Scientist, International Geophysical Year, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington 25, D. C.	1
University of Rochester, Atomic Energy Project, P. O. Box 287, Station 3, Rochester 20, New York ATTN: Tech Report Control Unit (For Dr. Herman E. Pearse)	1
Commander, U. S. Naval Air Development Center, Johnsville, Pa. ATTN: Dr. J. D. Hardy, Aviation Medical Acceleration Lab.	1
OTHERS	
Sandia Corporation, Sandia Base, Albuquerque, New Mexico ATTN: Classified Document Div (For Dr. E. F. COX)	1
Los Alamos Scientific Laboratory, P. O. Box 1663, Los Alamos, N. M. ATTN: Report Librarian (For Dr. Alvin C. Graves, J-Division)	1
Los Alamos Scientific Laboratory, P. O. Box 1663, Los Alamos, N. M. ATTN: Report Librarian	1
Technical Operations, Inc., 2000 P St., N.W., Rm 511, Washington 6, D.C. ATTN: Security Officer (For Mr. Greestone)	1
Medical College of Virginia, Box 222, Richmond, Va. ATTN: Maj. Gen. W. F. Tomkins (For Dr. William T. Ham)	1

Dist List No. 100

ADDRESSEE	OTHERS (Cont'd)	NO. OF COPIES
Director, California Forest and Range Experimental Station, U. S. Forest Service, P. O. Box 245, Berkeley, Calif. ATTN: W. L. Fons, Div. of Forest Fire Research		1
Massachusetts Institute of Technology, Director, Division of Defense Labs, Lincoln Lab, Cambridge 19, Mass. (For Prof. G. C. Williams)		1
Mr. H. D. Bruce, Forest Products Lab., North Walnut Street, Madison 5, Wisconsin		1
Chief, Fire Research Division, Forest Service, U. S. Department of Agriculture, Washington 25, D. C. ATTN: Mr. A. A. Brown		1

Naval Material Laboratory New York Naval Shipyard 5046-3, Part 96

THE THERMAL RADIATION CHARACTERISTICS OF NYLON FABRIC ASSEMBLIES by L. Banet and J. Bracciaventi. Final Report 5 June 1956. 9 p. Tables (AFSWP-954)

UNCLASSIFIED

The thermal radiation characteristics of four nylon fabric assemblies of uniform materials have been evaluated at the request of the Clothing Supply Office in connection with its assigned task to develop a uniform which will minimize the effects of the thermal radiation of nuclear weapons. The measurements include the critical thermal energies of the materials and the temperature rises of a skin simulating backing. The critical radiant energies required to produce a 2° mild burn on porcine skin are estimated

1. Nylon - Effects of radiation
2. Thermal radiation-Physiological effects

I. Banet, L.
II. Bracciaventi, J.
III. NS 081-001
IV. AFSWP-954

UNCLASSIFIED

Naval Material Laboratory New York Naval Shipyard 5046-3, Part 96

THE THERMAL RADIATION CHARACTERISTICS OF NYLON FABRIC ASSEMBLIES by L. Banet and J. Bracciaventi Final Report 5 June 1956. 9 p. Tables (AFSWP-954)

UNCLASSIFIED

The thermal radiation characteristics of four nylon fabric assemblies of uniform materials have been evaluated at the request of the Clothing Supply Office in connection with its assigned task to develop a uniform whichwill minimize the effects of the thermal radiation of nuclear weapons. The measurements include the critical thermal energies of the materials and the temperature rises of a skin simulating backing. The critical radiant energies required to produce a 2° mild burn on porcine skin are estimated.

1. Nylon - Effects of radiation
2. Thermal radiation-Physiological effects

I. Banet, L.
II. Bracciaventi, J.
III. NS 081-001
IV. AFSWP-954

UNCLASSIFIED

Naval Material Laboratory New York Naval Shipyard 5045-3, Part 96

THE THERMAL RADIATION CHARACTERISTICS OF NYLON FABRIC ASSEMBLIES by L. Banet and J. Bracciaventi. Final Report 5 June 1956. 9 p. Tables (AFSWP-954)

UNCLASSIFIED

The thermal radiation characteristics of four nylon fabric assemblies of uniform materials have been evaluated at the request of the Clothing Supply Office in connection with its assigned task to develop a uniform which will minimize the effects of the thermal radiation of nuclear weapons. The measurements include the critical thermal energies of the materials and the temperature rises of a skin simulating backing. The critical radiant energies required to produce a 2° mild burn on porcine skin are estimated.

1. Nylon - Effects of radiation
2. Thermal radiation-Physiological effects

I. Banet, L.
II. Bracciaventi, J.
III. NS 081-001
IV. AFSWP-954

UNCLASSIFIED

Naval Material Laboratory New York Naval Shipyard 5046-3, Part 96

THE THERMAL RADIATION CHARACTERISTICS OF NYLON FABRIC ASSEMBLIES by L. Banet and J. Bracciaventi Final Report 5 June 1956. 9 p. Tables (AFSWP-954)

UNCLASSIFIED

The thermal radiation characteristics of four nylon fabric assemblies of uniform materials have been evaluated at the request of the Clothing Supply Office in connection with its assigned task to develop a uniform which will minimize the effects of the thermal radiation of nuclear weapons. The measurements include the critical thermal energies of the materials and the temperature rises of a skin simulating backing. The critical radiant energies required to produce a 2° mild burn on porcine skin are estimated.

1. Nylon - Effects of radiation
2. Thermal radiation-Physiological effects

I. Banet, L.
II. Bracciaventi, J.
III. NS 081-001
IV. AFSWP-954

UNCLASSIFIED

Naval Material Laboratory New York Naval Shipyard 5046-3, Part 96

THE THERMAL RADIATION CHARACTERISTICS OF NYLON FABRIC ASSEMBLIES by L. Banet and J. Bracciaventi. Final Report 5 June 1956. 9 p. Tables (AFSWP-954)

UNCLASSIFIED

The thermal radiation characteristics of four nylon fabric assemblies of uniform materials have been evaluated at the request of the Clothing Supply Office in connection with its assigned task to develop a uniform which will minimize the effects of the thermal radiation of nuclear weapons. The measurements include the critical thermal energies of the materials and the temperature rises of a skin simulating backing. The critical radiant energies required to produce a 2° mild burn on porcine skin are estimated

1. Nylon - Effects of radiation
2. Thermal radiation- Physiological effects

I. Banet, L.
II. Bracciaventi, J.
III. NS 081-001
IV. AFSWP-954

UNCLASSIFIED

Naval Material Laboratory New York Naval Shipyard 5046-3, Part 96

THE THERMAL RADIATION CHARACTERISTICS OF NYLON FABRIC ASSEMBLIES by L. Banet and J. Bracciaventi Final Report 5 June 1956. 9 p. Tables (AFSWP-954)

UNCLASSIFIED

The thermal radiation characteristics of four nylon fabric assemblies of uniform materials have been evaluated at the request of the Clothing Supply Office in connection with its assigned task to develop a uniform whichwill minimize the effects of the thermal radiation of nuclear weapons. The measurements include the critical thermal energies of the materials and the temperature rises of a skin simulating backing. The critical radiant energies required to produce a 2° mild burn on porcine skin are estimated.

1. Nylon - Effects of radiation
2. Thermal radiation- Physiological effects

I. Banet, L.
II. Bracciaventi, J.
III. NS 081-001
IV. AFSWP-954

UNCLASSIFIED

Naval Material Laboratory New York Naval Shipyard 5046-3, Part 96

THE THERMAL RADIATION CHARACTERISTICS OF NYLON FABRIC ASSEMBLIES by L. Banet and J. Bracciaventi. Final Report 5 June 1956. 9 p. Tables (AFSWP-954)

UNCLASSIFIED

The thermal radiation characteristics of four nylon fabric assemblies of uniform materials have been evaluated at the request of the Clothing Supply Office in connection with its assigned task to develop a uniform which will minimize the effects of the thermal radiation of nuclear weapons. The measurements include the critical thermal energies of the materials and the temperature rises of a skin simulating backing. The critical radiant energies required to produce a 2° mild burn on porcine skin are estimated.

1. Nylon - Effects of radiation
2. Thermal radiation- Physiological effects

I. Banet, L.
II. Bracciaventi, J.
III. NS 081-001
IV. AFSWP-954

UNCLASSIFIED

Naval Material Laboratory New York Naval Shipyard 5046-3, Part 96

THE THERMAL RADIATION CHARACTERISTICS OF NYLON FABRIC ASSEMBLIES by L. Banet and J. Bracciaventi Final Report 5 June 1956. 9 p. Tables (AFSWP-954)

UNCLASSIFIED

The thermal radiation characteristics of four nylon fabric assemblies of uniform materials have been evaluated at the request of the Clothing Supply Office in connection with its assigned task to develop a uniform which will minimize the effects of the thermal radiation of nuclear weapons. The measurements include the critical thermal energies of the materials and the temperature rises of a skin simulating backing. The critical radiant energies required to produce a 2° mild burn on porcine skin are estimated.

1. Nylon - Effects of radiation
2. Thermal radiation- Physiological effects

I. Banet, L.
II. Bracciaventi, J.
III. NS 081-001
IV. AFSWP-954

UNCLASSIFIED